Initial Results from the High Energy Experiment *PDS* aboard *BeppoSAX*

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Abstract. The high energy experiment *PDS* is one of the Narrow Field Instruments aboard the X–ray astronomy satellite *BeppoSAX*. It covers the energy band from 15 to 300 keV. Here we report results on its in-flight performance and observations of galactic and extragalactic X–ray sources obtained during the Science Verification Phase of the satellite: in particular Crab, Cen X–3, 4U1626–67 and PKS2155–305.

INTRODUCTION

The Phoswich Detection System (*PDS*) is one of the Narrow Field Instrument aboard the X–ray astronomy satellite *BeppoSAX*, a program of the Italian Space Agency (ASI) with Dutch participation [1]. A detailed description of the instrument can be found in [2].

The *PDS* was designed to operate in the hard X–ray range from 15 to 300 keV and to perform high sensitivity spectroscopic and temporal studies of celestial X–ray sources, in particular their continuum emission. Classes of sources accessible to *PDS* include High Mass X–ray Binaries (HMXRB), Low Mass X–ray Binaries (LMXRB), Am Her–type sources, supernova remnants (in particular Crab-like sources) and Active Galactic Nuclei (AGN).

In this paper we report on functional performance of *PDS* and on some scientific results obtained from the observation of different classes of X–ray sources performed during the Science Verification Phase (SVP) of the *BeppoSAX* satellite.

IN-FLIGHT FUNCTIONAL PERFORMANCE

BeppoSAX was launched from Cape Canaveral with an Atlas-Centaur rocket

on April 30, 1996. Its orbit is almost equatorial (3.9°) at an altitude of 600 Km. During the *BeppoSAX* Commissioning Phase (1 May–30 June 1996), the *PDS* was switched on and tested. Since then all subsystems continue to properly operate with very good performance.

The anticoincidence (AC) shields provide a reduction of the background level by about a factor two with respect to the level obtained with the phoswich technique alone. In addition, the AC system strongly decreases the background modulation along the *BeppoSAX* orbit.

The background level B of the *PDS* is the lowest obtained thus far with high energy instruments at satellite orbits, specially at energies beyond 100 keV. In the 15–300 keV band, B is about 2.0×10^{-4} Cts cm^{-2} sec^{-1} keV^{-1}: this is $\sim 70\%$ of that published in the *BeppoSAX* handbook [3]. In 100–300 keV B is a factor 3 lower than that expected. The background modulation along a single *BeppoSAX* orbit and on one day time scale is about 20%, while longer term variations (*e.g.*, build-up effects) are negligible.

We evaluated the systematic error in the background subtraction introduced by the rocking collimator technique, by computing the background level variation between the ON- and OFF-source positions in 32 ksec observing time. We obtained 0.17 ± 0.09 mCrab in the 15–300 keV energy band, corresponding to a 5σ instrument sensitivity of 0.9 mCrab. This has to be compared to the value of 0.5 mCrab, if only Poisson statistics is taken into account.

SCIENTIFIC RESULTS

We will discuss some scientific results obtained with *PDS* during the *BeppoSAX* SVP, that show the actual spectral and timing capability of the instrument in flight.

Crab Nebula

The source has been observed for calibration purposes two times, in September 1996 (obs.I) and in April 1997 (obs.II). The spectral deconvolution makes use of a response function derived from a Monte Carlo code that describes the interaction of a photon beam with the *PDS* instrument, complemented by the ground calibrations [4].

By fitting the total spectrum of Crab with a single power law model we obtained a photon index α consistent for both observations: $\alpha = 2.119 \pm 0.002$ for obs.I and $\alpha = 2.112 \pm 0.003$ for obs.II. The normalization parameters at 1 keV are 8.60 ± 0.06 and 8.57 ± 0.04 for obs.I and obs.II, respectively. The fitting was not so good: the reduced χ^2 was 2.89 (77 dof) for obs.I and 3.09 (67 dof) for obs.II. These high χ^2 are partly due to a break in the Crab high energy spectrum also observed by other groups [5], and partly to wiggles in the count rate spectrum between 30 and 60 keV, whose instrumental origin is under investigation. These systematic effects are

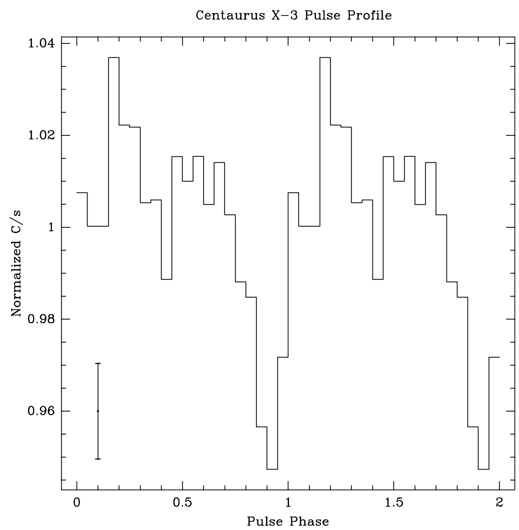

FIGURE 1. *BeppoSAX/PDS* pulse profile of the 4.84 sec X–ray binary pulsar Cen X–3.

estimated to be less than 5% in the residuals and less than 1% in the spectral index reconstruction.

We can conclude, from these results, that the photon index is consistent with previous results on the source spectrum [5], while the normalization parameter is about 10% lower than the extrapolation of the power law spectrum measured with the MECS instrument [6] aboard *BeppoSAX*. It is however consistent with published results on Crab [5] within their uncertainties.

Centaurus X–3

This classical X–ray pulsar, belonging to the class of HMXRBs, was observed for $\sim$ 6000 sec during a low intensity level (30 mCrab) at high energies. The source was clearly detected up to about 50 keV. The hard X–ray spectrum of the source is consistent with an optically thin thermal bremsstrahlung with $kT = 8.2 \pm 0.2$ keV and normalization parameter 0.66 ± 0.03. The plasma temperature and flux level are consistent with those measured by HEAO–1/A4 [7]. The *PDS* pulse profile of the pulsar ($P_P \sim 4.84$ sec) is characterized by a dip (see Fig. 1). It appears different from the average pulse profiles previously reported [7]. An investigation on the origin of this different behavior is under way.

4U1626–67

This X–ray pulsar ($P_P \sim 7.7$ sec) is one of the few LMXRBs that show pulsed emission. It was detected with *PDS* up to 50 keV in $\sim$ 70 ksec exposure time. The

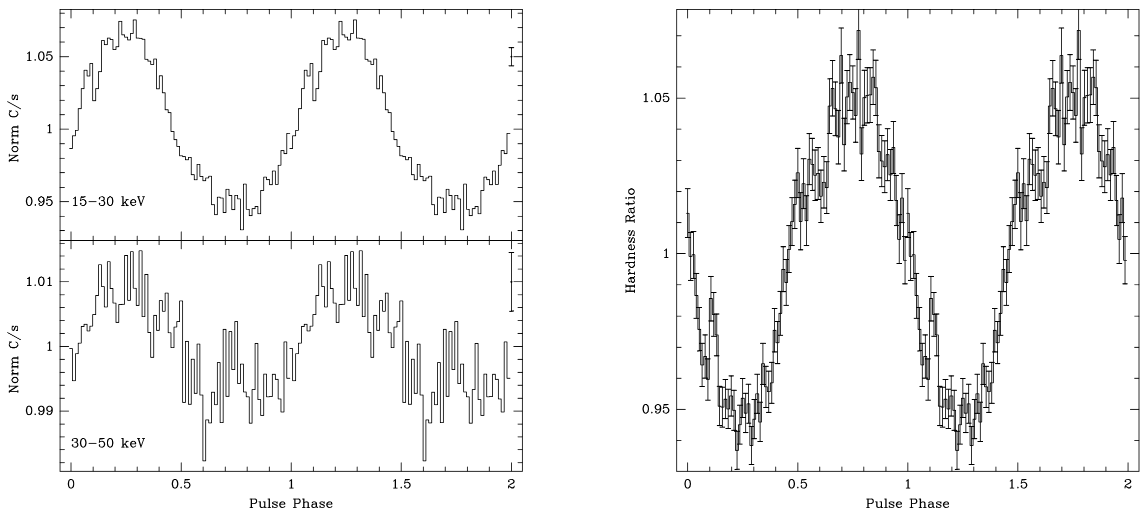

FIGURE 2. a): 4U1626–67 pulse profiles in two energy bands as observed by *PDS*. b): Hardness ratio between the 30–50 and 15–30 keV pulse profiles.

spectral analysis is in progress, while the pulse profiles of the pulsar in two hard X–ray ranges are shown in Fig. 2a. As can be seen, 4U1626–67 exhibits a sinusoidal shape and a peculiar feature: the hardness ratio between 30–50 keV and 10–30 keV pulse profiles turns out to be anti-correlated with the intensity profile (Fig. 2b).

PKS2155–304

PKS2155–304 is one of the strongest BL Lac objects in the 2–10 keV energy band. It is the first time the source has been simultaneously observed in a broad-energy band (0.1–300 keV), crucial for studying the relationship among different emission components. The source was clearly detected by *PDS* up to 100 keV (exposure time $\sim$ 100 ksec). The ratio between the source spectrum and the Crab spectrum is shown in Fig. 3. It is apparent that the source spectrum is softer than Crab below 10–20 keV, while it is harder or similar to the Crab spectral slope above 10–20 keV. An extended paper on the *BeppoSAX* results on this source can be found elsewhere [8].

The most probable interpretation of the hard X–ray component is Inverse Compton radiation associated to a Self-Synchro Compton (SSC) process, while the lower energy component is synchrotron radiation.

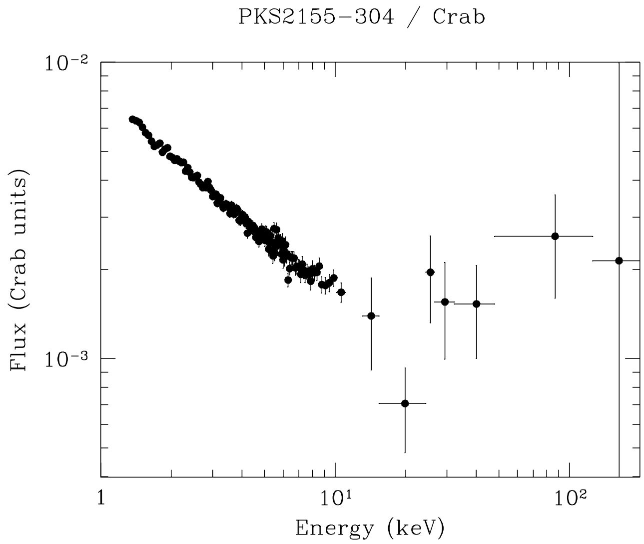

FIGURE 3. Observed ratio between PKS2155–305 and Crab spectra. Data from both MECS and *PDS* were used.

CONCLUSION

The SAX/PDS experiment is performing as designed and shows a flux sensitivity that is in agreement or better than that given in the *BeppoSAX* handbook [3].

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